PATENT ABSTRACTS OF JAPAN

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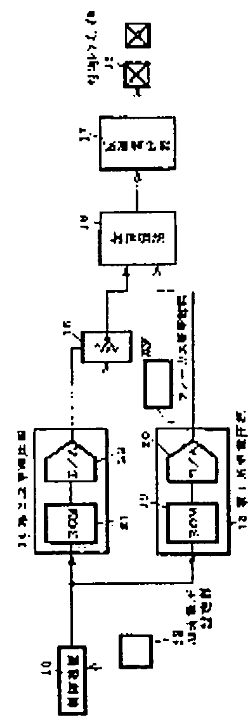
(71)Applicant : JEOL LTD

(72)Inventor : SHIBANO AKIRA
HARASAWA KIYOSHI

(54) OBJECTIVE LENS ENERGIZING CURRENT GENERATING SYSTEM

(57)Abstract:



PURPOSE: To minimize out of focusing in an SEM even though the acceleration voltage is varied over the whole stroke of objective lens motion.

CONSTITUTION: In a ROM 19 the first reference voltage is written, which corresponds to the optimum energization current for the acceleration voltage at the first WD. In a ROM 21 are written the second reference voltage corresponding to the optimum energization current for the acceleration voltage in the second WD, which is shorter than the first WD, and the differential voltage value of the first reference voltage. The output voltage of the second reference voltage source is added to the first reference voltage by an adding circuit 16 through a variable resistor 15 as a focus adjusting means. The output voltage of the adding circuit 16 is fed to an energization current source 17, where an energization current is generated accordingly and supplied to an objective lens coil 18.

LEGAL STATUS

[Date of request for examination]

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CLAIMS

[Claim(s)]
[Claim 1] The source of the 1st reference voltage which generates the 1st reference voltage corresponding to the optimal exciting current over the set-up acceleration voltage in the 1st objective lens working distance, The source of the 2nd reference voltage which generates the electrical potential difference of the difference of the 2nd reference voltage corresponding to the optimal exciting current over the set-up acceleration voltage in the 2nd objective lens working distance shorter than said 1st objective lens working distance, and said 1st reference voltage, The electrical-potential-difference adjustable means which carries out adjustable [of the output voltage of said source of the 2nd reference voltage], and an addition means to add said 1st reference voltage and the output voltage of said electrical-potential-difference adjustable means, The exciting-current generating method of the objective lens characterized by having the excitation current source which generates the exciting current supplied to an objective lens based on the output voltage of said addition means.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the exciting-current generating method of the objective lens in a scanning electron microscope (SEM), an electron probe X-ray microanalyser, electron ray length measurement equipment (SEM etc. is called hereafter), etc.
[0002]
[Description of the Prior Art] In SEM etc., it is common that the acceleration voltage of the objective lens working distance (working distance: WD) and an electron ray is made by adjustable. And where WD is fixed, when changing acceleration voltage, in order to prevent that a focus shifts, it is made as [change / according to change of acceleration voltage / the exciting current of an objective lens]. The outline of a configuration for that is shown in drawing 3 .
[0003] The acceleration voltage setting section 2 which consists of a ten key or a knob in the condition that WD was defined is operated, and the control unit 1 which consists of a microprocessor in drawing 3 is the new acceleration voltage VH. If what was directed is detected, it is the acceleration voltage VH concerned. The digital value of VH 1/2 which is a square root is outputted. This digital value is changed into an analog signal with D/A converter 3, and the partial pressure of it is carried out by the variable resistance 4 which functions as a focal adjustment device, and it is supplied to the excitation supply current 5. From the excitation supply current 5, the exciting current proportional to VH 1/2 is generated, and the objective lens coil 6 is supplied by this. In addition, in drawing 3 , 7 is a focal adjustment device which consists of a knob, turns a knob and controls variable resistance 4.
[0004]
[Problem(s) to be Solved by the Invention] However, when the magnetic pole which constitutes an objective lens is saturated in the conventional configuration shown in drawing 3 , when [even if not saturated completely,] the nonlinearity of the B-H curve of the pole piece concerned influenced, or when the residual magnetization resulting from a hysteresis etc. influenced, it could not respond, but when changing acceleration voltage, there was a problem that a focal gap occurred.
[0005] Namely, when a paraxial trajectory equation in case the configuration shown in drawing 3 does not have an electric potential gradient makes electronic specific charge and phi acceleration voltage and makes [the orbit of the electron in a system of rotating axes] B a shaft top magnetic field for X and e/m, It is expressed with X"+(eB2/8mphi) X=0, and they are B-2/phi. It is a parameter, And it is what is constituted based on the matter in which the field on a shaft is proportional to the exciting current supplied to an objective lens in the conditions that there is no saturation of a magnetic pole and the permanent magnet is not used for an objective lens at all. Therefore, although it is a very effective configuration when the two above-mentioned conditions are satisfied When a magnetic pole is saturated, when [even if not saturated completely,] the nonlinearity of the B-H curve of the magnetic pole concerned influences, or when the residual magnetization resulting from a hysteresis etc. influences Since the above-mentioned conditions are not satisfied, when acceleration voltage is changed, a focal gap will arise. And since a peak magnetic field generally becomes weak when the lens which has a pole

piece is saturated In order to keep a focal point constant, it is the acceleration voltage VH at that time. A bigger exciting current than the current proportional to a square root VH 1/2 is needed. Moreover, since the magnetic field strength of an objective lens increases with the increment in an exciting current The effect of the saturation of a pole piece has a large time of changing WD to the shorter one, when changing WD, where acceleration voltage is fixed, and where WD is kept constant, when changing acceleration voltage, the time of effect of changing acceleration voltage to the larger one is large. That is, the exciting current for keeping a focal point constant becomes like 30, 31, and 33 of drawing 2 .

[0006] On the other hand, where WD is fixed, when changing acceleration voltage, VH 1/2 is not inputted to D/A converter 3. As shown in drawing 4 , WD is read from the focal adjustment device 7. Although the focal gap when changing acceleration voltage can be prevented if the value (a wavy line is attached and shown on in [VH / 1/2] drawing) made to transform VH 1/2 in consideration of the saturation of the pole piece corresponding to the WD etc. is inputted In that case, it must have the table which wrote the output voltage for every acceleration voltage in the control device 1 to all WD(s), and memory space becomes huge.

[0007] This invention aims at solving the above-mentioned technical problem and offering the exciting-current generating method of the objective lens which is an easy configuration, and a focal gap does not produce when the nonlinearity of the B-H curve of the pole piece of an objective lens influences, or when the residual magnetization resulting from a hysteresis etc. influences and acceleration voltage is changed in all WD(s).

[0008]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, the exciting-current generating method of the objective lens of this invention The source of the 1st reference voltage which generates the 1st reference voltage corresponding to the optimal exciting current over the set-up acceleration voltage in the 1st objective lens working distance, The source of the 2nd reference voltage which generates the electrical potential difference of the difference of the 2nd reference voltage corresponding to the optimal exciting current over the set-up acceleration voltage in the 2nd objective lens working distance shorter than said 1st objective lens working distance, and said 1st reference voltage, It is characterized by having the electrical-potential-difference adjustable means which carries out adjustable [of the output voltage of said source of the 2nd reference voltage], an addition means to add said 1st reference voltage and the output voltage of said electrical-potential-difference adjustable means, and the excitation current source which generates the exciting current supplied to an objective lens based on the output voltage of said addition means.

[0009]

[Function] The source of the 1st reference voltage generates the 1st reference voltage corresponding to the optimal exciting current over the set-up acceleration voltage in the 1st objective lens working distance. The source of the 2nd reference voltage generates the electrical potential difference of the difference of the 2nd reference voltage and the 1st reference voltage corresponding to the optimal exciting current over the set-up acceleration voltage in the 2nd objective lens working distance shorter than the 1st objective lens working distance. By the electrical-potential-difference adjustable means as a focal adjustment device, suitably, the output voltage of the source of the 2nd reference voltage is made as adjustment is possible. The output voltage of the electrical-potential-difference adjustable means concerned is added with the output voltage of the source of the 1st reference voltage by the addition means, the exciting current corresponding to the output voltage of this addition means is generated in an excitation current source, and this exciting current is supplied to the coil of an objective lens.

[0010]

[Example] Hereafter, an example is explained, referring to a drawing. drawing showing the configuration of one example of the exciting-current generating method of the objective lens which drawing 1 requires for this invention -- it is -- the inside of drawing, and 10 -- a control unit and 11 -- a focal adjustment device and 12 -- the acceleration voltage setting section and 13 -- the source of the 1st reference voltage, and 14 -- the source of the 2nd reference voltage, and 15 -- variable resistance and 16 -- an adder circuit and 17 -- a D/A converter and 21 show ROM and, as for an objective lens coil and 19,

22 shows a D/A converter for an excitation current source and 18, as for ROM and 20.
[0011] Actuation of the configuration of drawing 1 is as follows. A control unit 10 consists of microcomputers, and if acceleration voltage is set up by the acceleration voltage setting section 12 which consists of a ten key, a knob, etc., it will output the digital value of the set-up acceleration voltage to the source 13 of the 1st reference voltage, and the source 14 of the 2nd reference voltage.
[0012] The source 13 of the 1st reference voltage consists of ROM19 and D/A converter 20. The curved data shown by 30 of drawing 2 are written in ROM19, and the 1st reference voltage is outputted by making into the address digital acceleration voltage outputted from a control device 10. This 1st reference voltage is changed into an analog signal by D/A converter 20, and is inputted into one input terminal of an adder circuit 16. This curve 30 defines the 1st reference voltage corresponding to the optimal objective lens exciting current which the focal gap to the acceleration voltage in the longest WD (s), such as the 1st predetermined WD, for example, the SEM concerned etc., does not produce. Such a curve 30 can set WD as the WD concerned in the SEM concerned etc. beforehand, can search for the exciting current which the focal gap when changing acceleration voltage does not produce, and can create it by making a desired electrical potential difference correspond to the exciting current. In addition, the axis of ordinate of drawing 2 is acceleration voltage VH about reference voltage. It is the value broken by the square root, and this value is acceleration voltage VH about an exciting current. It is a value proportional to the value broken by the square root.
[0013] The source 14 of the 2nd reference voltage consists of ROM21 and D/A converter 22. The difference of the curved data shown by 30 of drawing 2 and the curved data shown by 31 is written in ROM21, and the electrical potential difference of the difference concerned is outputted by making into the address digital acceleration voltage outputted from a control device 10. The output voltage of ROM21 is changed into an analog signal by D/A converter 22, and is impressed to the end of variable resistance 15. This curve 31 defines the 2nd reference voltage corresponding to the optimal objective lens exciting current which the focal gap to the acceleration voltage in the shortest WD(s), such as the 2nd predetermined WD shorter than WD of a curve 30, for example, the SEM concerned etc., does not produce. Like a curve 30, such a curve 31 sets WD as the WD concerned in the SEM concerned etc. beforehand, can search for the exciting current which the focal gap when changing acceleration voltage does not produce, can create it by making a desired electrical potential difference correspond to the exciting current, and can obtain further the data written in ROM21 from the difference of the 1st reference voltage and the 2nd reference voltage in the same acceleration voltage.
[0014] Therefore, supposing acceleration voltage is set as VH1 of drawing 2 by the acceleration voltage setting section 12 in a certain WD From a control device 10, the digital value of the acceleration voltage VH1 concerned is outputted to the source 13 of the 1st reference voltage, and the source 14 of the 2nd reference voltage. From ROM19 of the source 13 of the 1st reference voltage, Vref1 is outputted as the 1st reference voltage, and it is **V1 from ROM21 of the source 14 of the 2nd reference voltage. It is outputted and is changed into analog voltage with D/A converters 20 and 22, respectively. In addition, in drawing 2 , the boundary of the range which can disregard the effect of the magnetic saturation of an objective lens pole piece, and the range which cannot be disregarded is shown, the effect of the magnetic saturation of an objective lens pole piece appears on the right-hand side of a broken line 32, and, on the left-hand side, the effect of the magnetic saturation of an objective lens pole piece can disregard a broken line 32.
[0015] The output voltage of the source 14 of the 2nd reference voltage is impressed to the end of variable resistance 15 which functions as a focal adjustment device. The other end of variable resistance 15 is grounded. The output voltage from variable resistance 15 is inputted into the input terminal of another side of an adder circuit 16, and is added with the 1st reference voltage. Therefore, supposing acceleration voltage is now set as VH1 by the acceleration voltage setting section 12, by adjusting variable resistance 15, adjustable [of the output voltage of an adder circuit 16] can be carried out in VH1 - (VH1+**V1) the range, and, thereby, focal adjustment can be performed. The output voltage of an adder circuit 16 is inputted into the excitation current source 17, and from the excitation current source 17, the exciting current corresponding to the output voltage of an adder circuit 16 is generated,

and it is supplied to the objective lens coil 18 by this.

[0016] Therefore, when changing acceleration voltage in all WD(s), a focus can be easily doubled only by adjusting variable resistance 15. For example, if a curve 30 is made into the curve corresponding to the optimal exciting current in the longest WD(s), such as the SEM concerned, and a curve 31 is made into the curve corresponding to the optimal exciting current in the shortest WD In WD which a focal gap does not arise and needs the middle exciting current exactly even if it changes acceleration voltage in the longest and the shortest WD The curve 37 which divided the curve 31 and the curve 30 proportionally to 1:1 when setting variable resistance 15 as the central location is formed. Although there is no guarantee of this 37 curve which is always in agreement in the optimal exciting current 33 of a continuous line, the degree of the gap from the broken line 36 of a curve 33 Considering being middle extent of the degree of the gap from the broken line 34 of a curve 30, and the degree of the gap from the broken line 35 of a curve 31, there are few gaps of a curve 37 and a curve 33. Therefore, extent of the focal gap is small and a focus can be easily doubled only by adjusting variable resistance 15 slightly. This is the same also in other WD(s).

[0017] As mentioned above, although one example of this invention was explained, this invention is not limited to the above-mentioned example, and various deformation is possible for it. For example, the 1st and 2nd reference voltage does not necessarily need to correspond to the optimal exciting current in the longests, such as the SEM concerned, and the shortest WD, and can be defined if needed in consideration of the range of WD where operating frequency is high. Moreover, although the source of the 1st reference voltage and the source of the 2nd reference voltage shall be equipped with ROM in the above-mentioned example, respectively, it is made to prepare for a control unit by using as a table the data shown in drawing 2 , and you may make it output the electrical potential difference of the difference of the 1st reference voltage and the 1st reference voltage, and the 2nd reference voltage directly from a control unit. in addition, it is in difference that the source of the 1st and 2nd reference voltages will consist of only D/A converters in this case.

[0018]

[Effect of the Invention] When the exciting current for taking a focus by the magnetic saturation of the pole piece of an objective lens etc. shifts from the value proportional to the square root of acceleration voltage, even if it changes acceleration voltage to all WD(s), according to this invention, a focus can be easily doubled, so that clearly from the above explanation. Moreover, since the configuration of this invention should just add ROM, an adder circuit, etc. to the conventional configuration, it can be constituted cheaply.

[Translation done.]

* NOTICES *

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is drawing showing the configuration of one example of this invention.
[Drawing 2] It is drawing for explaining the data written in ROM.
[Drawing 3] It is drawing showing the conventional example of a configuration.
[Drawing 4] It is drawing showing other conventional examples of a configuration.
10 [-- The source of the 1st reference voltage, 14 / -- The source of the 2nd reference voltage, 15 / -- Variable resistance, 16 / -- An adder circuit, 17 / -- An excitation current source, 18 / -- An objective lens coil, 19 / -- ROM, 20 / -- A D/A converter, 21 / -- ROM, 22 / -- D/A converter.] -- A control unit, 11 -- A focal adjustment device, 12 -- The acceleration voltage setting section, 13

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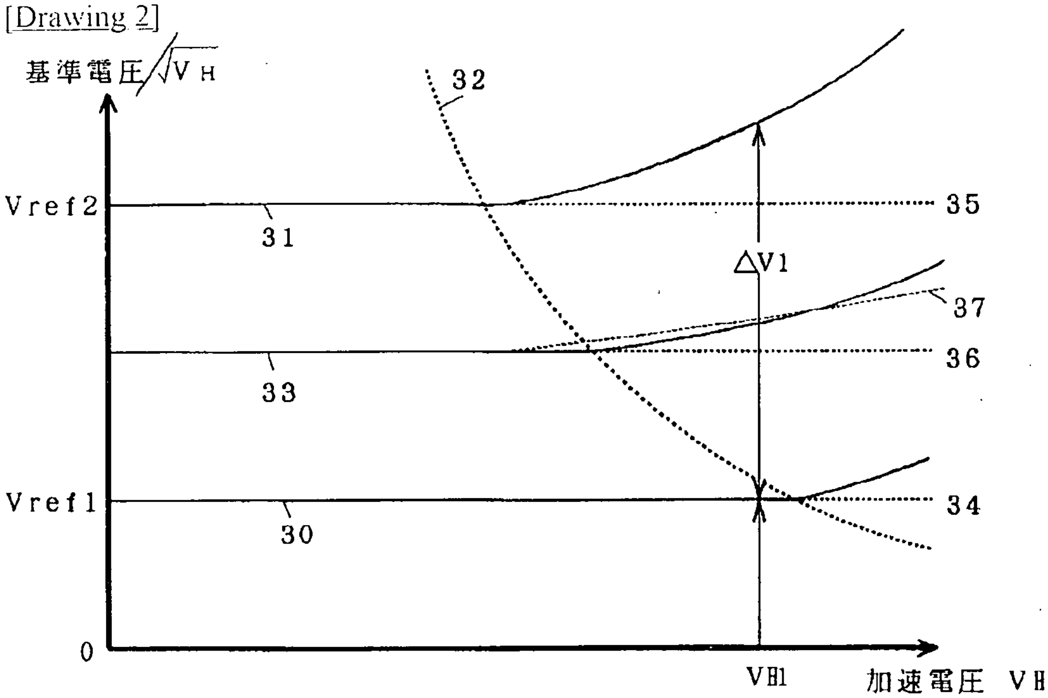
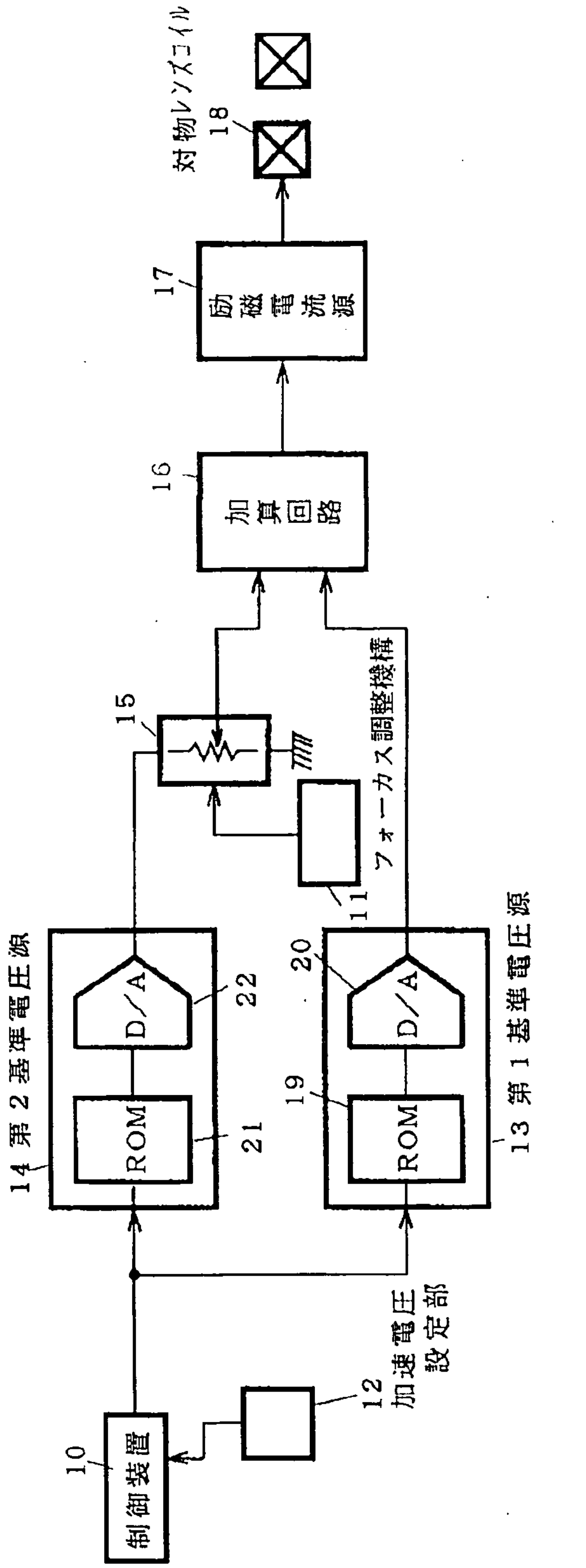
DRAWINGS

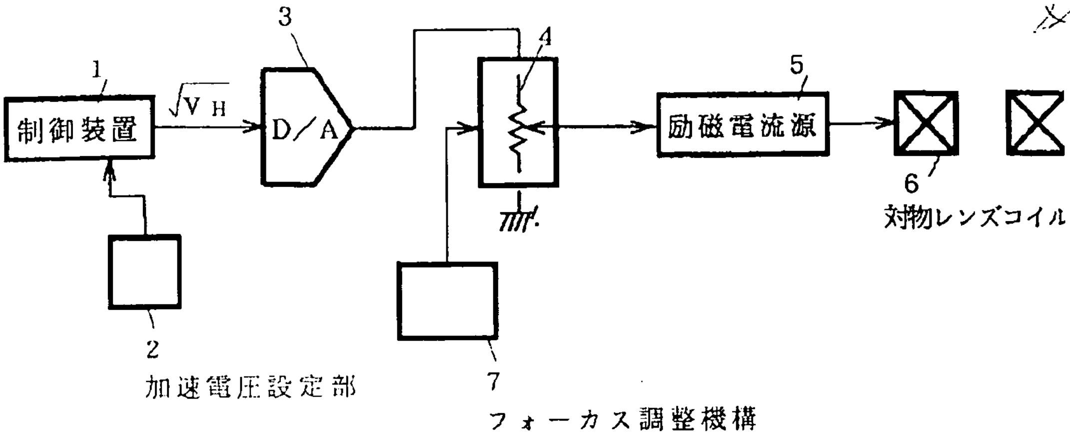
[Drawing 2]



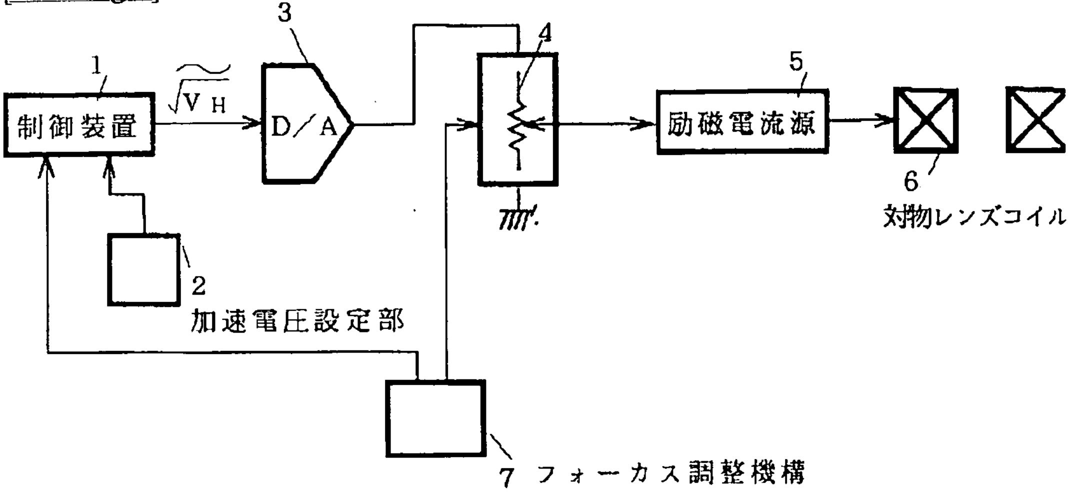
[Drawing 1]


10 制御装置
12 加速電圧設定部
14 第2基準電圧源
13 第1基準電圧源
ROM
D／A
19
20
21
22
11
フォーカス調整機構
15
16 加算回路
17 励磁電流源
18 対物レンズコイル

[Drawing 3]



[Drawing 4]



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